

Claims

- 5 1. A device (1) for routing data units in a network (3),
comprising
- 10 a receiver (10) for receiving data units from said
network,
- a buffer (111) for buffering data units received by said
receiver,
- 15 an output unit (12) for outputting buffered data units
to said network on the basis of routing information
contained in said data units,
- 20 a congestion monitor (110) for monitoring whether said
device fulfils a predetermined congestion condition,
- 25 a congestion notification unit (110) for setting
congestion notification information in one or more data
units output by said output unit, if said congestion
monitor determines that said congestion condition is
fulfilled,
- characterized by
- 30 a congestion cause identifying unit (110) capable of
distinguishing between at least two different congestion
causes, for identifying one or more causes of said
congestion monitor detecting that said congestion
condition is fulfilled, and
- 35 said congestion notification unit being arranged for
setting congestion cause information based on the one or
more causes identified by said congestion cause

identifying unit in said one or more data units in which congestion notification information is set.

- 5 2. A device according to claim 1, wherein said congestion monitor is arranged to monitor the degree of utilization of one or more resources of said device, and to determine that the congestion condition is fulfilled if the degree of utilization of at least one of said one or more resources fulfils a predetermined condition.
- 10 3. A device according to claim 2, wherein said predetermined condition is the exceeding of a predetermined threshold.
- 15 4. A device according to one of claims 1 to 3, wherein said congestion cause identifying unit is arranged to observe the degree of utilization of two or more resources of said device, and to identify said one or more causes on the basis of the observed degrees of utilization.
- 20 5. A device according to one of claims 2 to 4, wherein said resources comprise a buffering capacity and a data unit processing capacity.
- 25 6. A device according to claim 4 or 5, wherein said resources are grouped into one or more first resources and one or more second resources, and said congestion cause identifying unit is arranged to identify a first cause on the basis of the degree of utilization of said first resources and a second cause on the basis of the degree of utilization of said second resources.
- 30 7. A device according to claim 6, wherein said first resources comprise one or both of
 - 35 - a buffering capacity associated with said receiver for buffering data units upon receipt by said receiver, and

- a processing capacity for controlling a transfer of data units from said receiver to said output unit, and said second resources comprise one or both of

- a buffering capacity associated with said output unit for buffering data units to be output, and
- a processing capacity for controlling the output of data units from said output unit.

8. A method of controlling a device for routing data units in a network, comprising

receiving data units from said network,

buffering data units received by said receiver,

outputting buffered data units to said network on the basis of routing information contained in said data units,

monitoring whether a predetermined congestion condition is fulfilled,

setting congestion notification information in one or more output data units if said congestion condition is fulfilled,

characterized by

identifying (S22) one or more causes of said congestion condition being fulfilled, and

setting (S23) congestion cause information based on the one or more identified causes in said one or more data units in which congestion notification information is set.

- 5 9. A method according to claim 8, wherein the degree of utilization of one or more resources of said device is monitored, and it is determined that the congestion condition is fulfilled if the degree of utilization of at least one of said one or more resources fulfils a predetermined condition.
- 10 10. A method according to claim 9, wherein said predetermined condition is the exceeding of a predetermined threshold.
- 15 11. A method according to one of claims 8 to 10, wherein the degree of utilization of two or more resources of said device is observed, and said one or more causes are identified on the basis of the observed degrees of utilization.
- 20 12. A method according to one of claims 9 to 11, wherein said resources comprise a buffering capacity and a data unit processing capacity.
- 25 13. A method according to claim 11 or 12, wherein said resources are grouped into one or more first resources and one or more second resources, and a first cause is identified on the basis of the degree of utilization of said first resources and a second cause is identified on the basis of the degree of utilization of said second resources..
- 30 14. A method according to claim 13, wherein said first resources comprise one or both of
- a buffering capacity associated with said receiver for buffering data units upon receipt by said receiver, and
 - a processing capacity for controlling a transfer of
- 35 data units from said receiver to said output unit, and said second resources comprise one or both of

- a buffering capacity associated with said output unit for buffering data units to be output, and
- a processing capacity for controlling the output of data units from said output unit.

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15. A computer program for executing the method of one of claims 8 to 14 when run on a device for routing data units in a network.

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16. A data carrier storing the computer program of claim 15.

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17. A communication device (31) for sending data units to a receiving communication device (32) over a network (3), said communication device for sending being arranged to receive from said receiving data communication device acknowledgment messages that contain receipt information regarding the receipt of sent data units and congestion notification information regarding congestion in the network, said communication device for sending being arranged to respond to said acknowledgment messages by adapting an operation of controlling the sending of data units in accordance with the information contained in said acknowledgment messages,

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characterized in that

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said communication device for sending is arranged to extract congestion cause information contained in said acknowledgment messages, and to adapt the operation of controlling the sending of data units in accordance with said congestion cause information.

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18. A device according to claim 17, wherein the congestion cause information is designed such that the congestion cause information in an acknowledgment message can indicate the presence or absence of n different causes of congestion, such that each acknowledgment message

containing congestion cause information contains one of
2ⁿ different combinations of congestion causes, n being
an integer, and said communication device for sending is
arranged to identify the congestion cause combination
5 contained in an acknowledgment message and to invoke a
response procedure corresponding to the identified
congestion cause combination.

19. A device according to claim 17 or 18, wherein said
10 communication device for sending is arranged to extract
at least a first and a second congestion cause
information, said first congestion cause information
being associated with congestion due to the incapacity
to handle the number of data units being transported,
15 and said second congestion cause information being
associated with congestion due to the incapacity to
handle the amount of data being transported, and said
communication device for sending is arranged to respond
to the extraction of said first congestion cause
20 information by reducing the number of data units output
per unit of time, and to respond to the extraction of
said second congestion cause information by reducing the
amount of data output per unit of time.

20. A method for controlling a sending communication device
25 that is sending data units to a receiving communication
device over a network, comprising:
receiving from said receiving communication device
acknowledgment messages that contain receipt information
30 regarding the receipt of sent data units and congestion
notification information regarding congestion in the
network,
responding to said acknowledgment messages by adapting
an operation of controlling the sending of data units in
35 accordance with the information contained in said
acknowledgment messages,

characterized by

extracting (S62) congestion cause information contained
in said acknowledgment messages at said sending
communication device, and
adapting (S63) the operation of controlling the sending
of data units in accordance with said extracted
congestion cause information.

21. A method according to claim 20, wherein the congestion
cause information is designed such that the congestion
cause information in an acknowledgment message can
indicate the presence or absence of n different causes
of congestion, such that each acknowledgment message
containing congestion cause information contains one of
 2^n different combinations of congestion causes, n being
an integer, and said method further comprising:
identifying the congestion cause combination contained
in an acknowledgment message and
invoking a response procedure corresponding to the
identified congestion cause combination.
22. A method according to claim 20 or 21, wherein said
sending communication device is arranged to extract at
least a first and a second congestion cause information,
said first congestion cause information being associated
with congestion due to the incapacity to handle the
number of data units being transported, and said second
congestion cause information being associated with
congestion due to the incapacity to handle the amount of
data being transported, and said method further
comprising:
responding to the extraction of said first congestion
cause information by reducing the number of data units
output per unit of time, and

responding to the extraction of said second congestion cause information by reducing the amount of data output per unit of time.

- 5 23. A computer program for executing the method of one of claims 20 to 22 when run on a device for sending data units over a network.
24. A data carrier storing the computer program of claim 23.
- 10 25. A method of sending data units over a network (3), comprising:

15 sending data units into said network out of a sending communication device (31) connected to said network,

forwarding said data units in one or more routing devices (33-44) of said network to a receiving communication device (32) connected to said network,

20 each routing device buffering data units received from said network, outputting buffered data units to said network on the basis of routing information contained in said data units, monitoring whether a predetermined congestion condition is fulfilled, setting congestion

25 notification information in one or more output data units if said congestion condition is fulfilled, identifying one or more causes of said congestion condition being fulfilled, and setting congestion cause information based on the one or more identified causes

30 in said one or more data units in which congestion notification information is set,

receiving said forwarded data units at said receiving communication device, said receiving communication

35 device sending acknowledgment messages into said network, said acknowledgment messages containing receipt information regarding the receipt of said forwarded data

units as well as congestion notification information and congestion cause information set by said one or more routers in said forwarded data units,

5 forwarding said acknowledgment messages through said network to said sending communication device,

receiving said acknowledgment messages at said sending communication device and responding to said
10 acknowledgment messages by adapting an operation of controlling the sending of data units in accordance with the information contained in said acknowledgment messages, extracting said congestion cause information contained in said acknowledgment messages at said
15 sending communication device, and adapting the operation of controlling the sending of data units in accordance with said extracted congestion cause information.